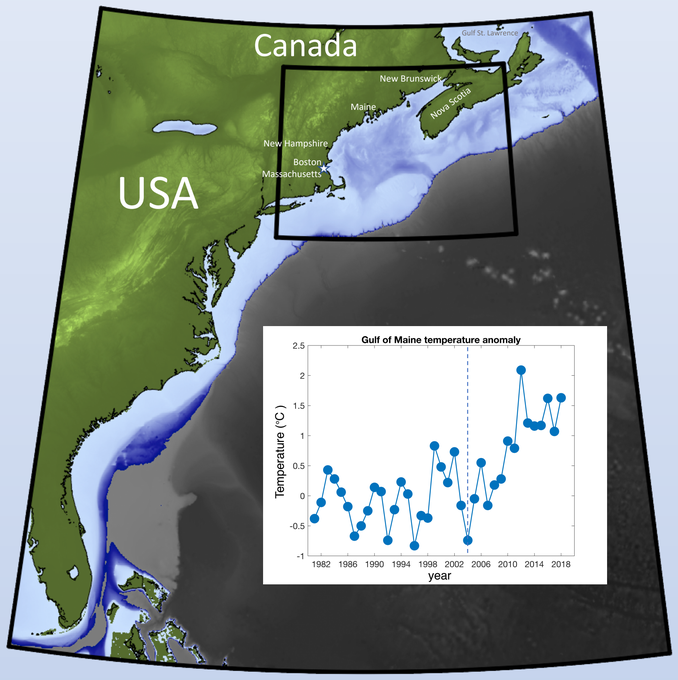
Program ID# 454

Entanglements of North Atlantic right whales increase as their distribution shifts in response to climate change: The need for a new management paradigm

Daniel Pendleton[1], Heather Pettis[1], Philip Hamilton[1], Amy Knowlton[1],
Scott Landry[2], Michael J Moore[3], William McLellan[4], Peter Corkeron[1], Scott Kraus[1]
1.Anderson Cabot Center for Ocean Life at the New England Aquarium, Boston MA USA. 2.Center for Coastal Studies, Provincetown MA USA.
3.Woods Hole Oceanographic Institution, Woods Hole MA USA. 4.University of North Carolina Wilmington, Wilmington VA USA.

Rapid warming in the Gulf of Maine linked to right whale distribution changes since ~2008 - 2012



Increasing Gulf of Maine temperature trend start date = 2004[μ]

What may have caused increased entanglement rates?

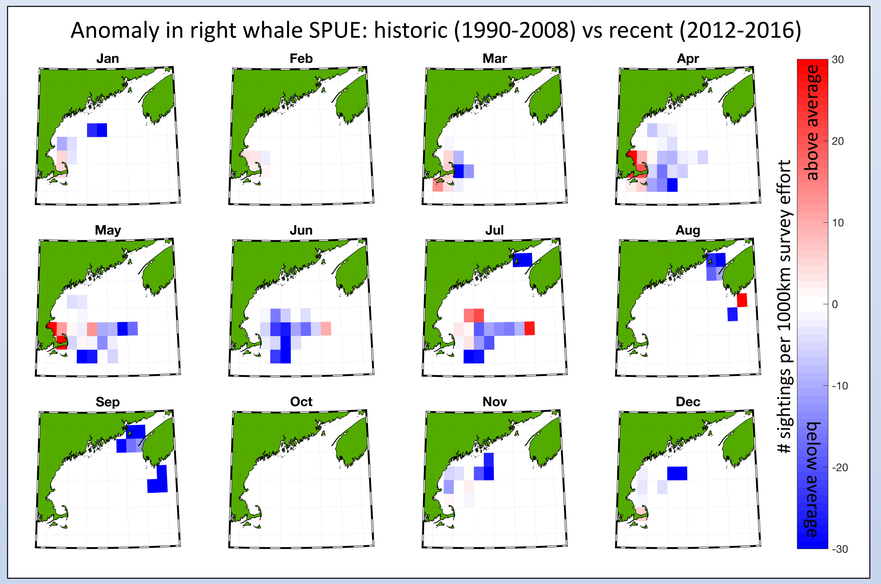
OBSERVATION Rapid warming at surface and at depth began ~2004 resulted in:

- changed supply of NARW prey[∂]
- redistribution of NARW
- increased lobster recruitment[ƒ]
- changed seasonality of fishery[μ]

HYPOTHESIS Warming waters have led to higher GOM lobster recruitment and more fishing activity (e.g., more rope and/or longer fishing seasons), leading to greater encounter rate between whales and rope as NARWs forage outside of historic feeding grounds.

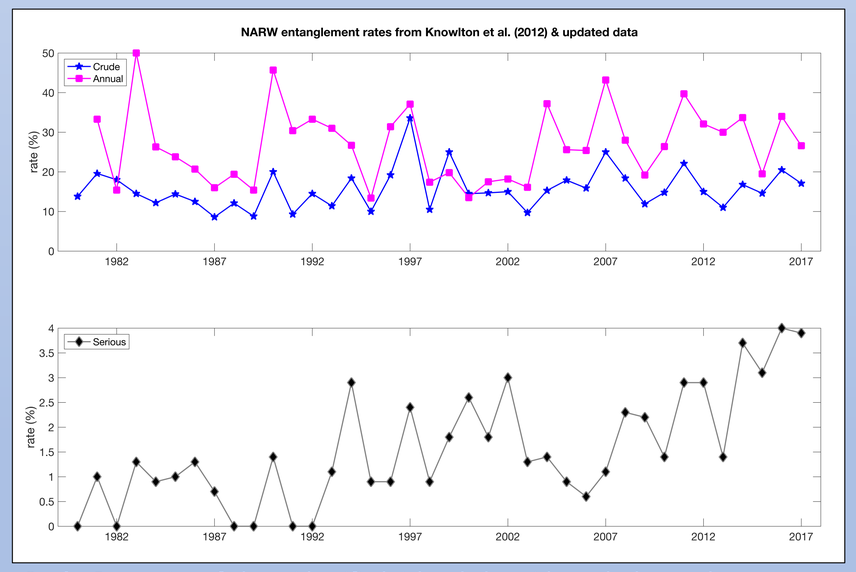
OBJECTIVE OF THIS ANALYSIS Address our hypothesis given extremely limited data on fixed gear fishing activity and the times and locations of entanglement events.

Redistribution of NARWs post ~2010



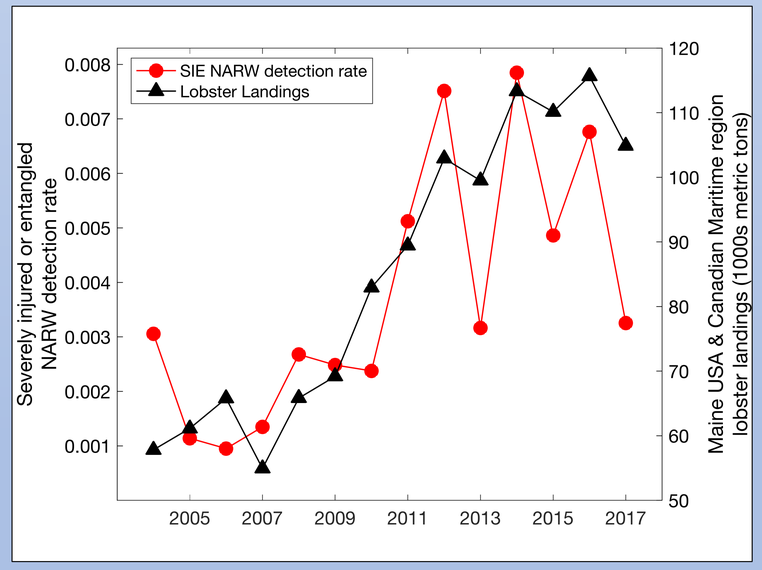
Detection rate of severely injured or entangled NARWs began to increase around 2004 - 2007

Knowlton et al (2012) entanglement rates updated through 2017

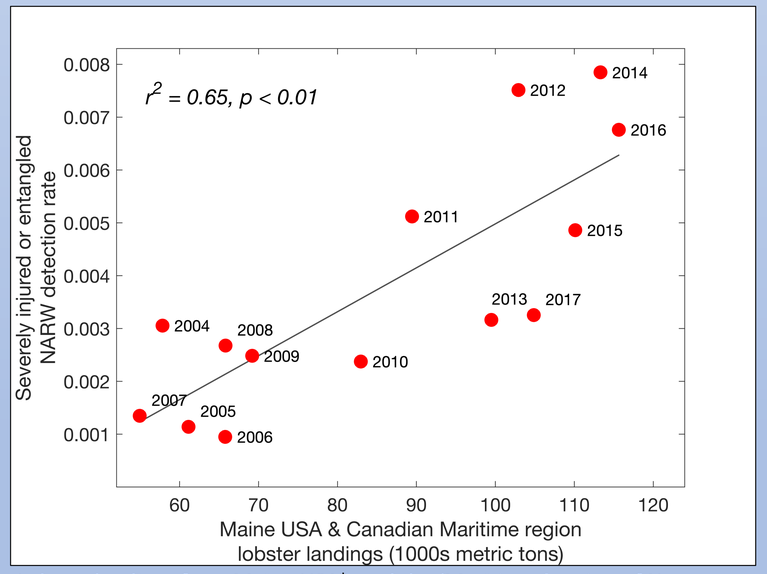


Crude: Proportion of photo-identified right whales with newly detected entanglement scars each year.
Annual: Percent of animals that showed definite evidence of a new entanglement by the second of 2 consecutive years in which they were sighted.
Serious: Number of right whales carrying gear or with severe injuries divided by the number of individuals photo-identified.

Increased landings from fixed-gear fisheries that overlap with NARW habitat. Increased rate of observed severe injury & entanglement



Detection rate of severely injured or entangled (SEI) NARWs calculated as # detections of SIE NARWs divided by # NARW sightings. Analysis does not account for heterogeneous capture rates across individual NARWs. **Caveat** We acknowledge that increased landings do not necessarily equal increased fishing effort.



Lobster landings from Maine USA[†], and the 'Maritimes' region of Nova Scotia & New Brunswick, Canada[¥]. Maritimes region includes Bay of Fundy and Scotian Shelf, and does not include the Gulf of St Lawrence. Known SIE events from the Gulf of St Lawrence were not included in this analysis. Crab and gillnet fisheries were not included in this analysis although they are also known to be a threat.

Climate change has changed NARW distributions in a nonlinear and unpredictable fashion
Dynamic management of fisheries that threaten species facing extinction is too risky, since managers cannot respond quickly enough
Broadscale changes to fishing practices are needed to minimize and eliminate human-caused injury and mortality

References:
† Maine lobster landings data from maine.gov/dmr/.
¥ Canadian lobster landings data for New Brunswick & Nova Scotia Maritimes regions from dfo-mpo.gc.ca/stats/commercial/.
ƒ Le Bris et al. (2018) Climate vulnerability and resilience in the most valuable North American fishery. Proc Natl Acad Sci USA 115:1831–1836.

References:
μ Mills, Pershing, et al. (2013) Fisheries Management in a Changing Climate: Lessons From the 2012 Ocean Heat Wave in the Northwest Atlantic. Oceanography 26.
∂ Record et al. (2019) Rapid Climate-Driven Circulation Changes Threaten Conservation of Endangered North Atlantic Right Whales. Oceanog 32:162–169.
Knowlton et al. (2012) Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: a 30 yr retrospective. Marine Ecology Progress Series 466:293–302.

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